Exploring Biotechnology: A Pathway to Prosperity in Rural and Urban Oregon?

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Principal Investigator: Bridgid Backus, Ph.D.
Co-Principal Investigator: Warren Coffeen, Ph.D.
Co-Principal Investigator: Daniel Lara
Project Manager: Karin Magnuson, M.Ed.

Linn-Benton Community College
6500 Pacific Blvd SW
Albany, OR 97321

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Linn-Benton COMMUNITY COLLEGE

6500 Pacific Blvd SW
Albany, OR 97321
www.linnbenton.edu

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Biotechnology training programs in the U.S. are important in the preparation of the professional technical workforce. Projections through 2020 show the prospect for a number of new and replacement technician level jobs added to the state's scientific workforce. Through an Advanced Technology Education (ATE) Center Planning Grant, Linn-Benton Community College (LBCC) engaged potential partners in the identification of current and long-term (5-10 year) occupational and workforce training needs for the Oregon biotechnology industry.

Focusing on a common set of competencies for bioscience technicians the planning grant sought to determine: (a) the need for an ATE Regional Center of Excellence in the Willamette Valley, (b) the ideal location for such a center, (c) the technician skill sets that meet existing industry needs, (d) a biotechnology program curriculum that is interdisciplinary, competency-based, and occupationally verified, and (e) career pathways that allow for transition from secondary schools through the community college and into entry level employment in the biotechnology sector or onto further educational opportunities at the university level.

This investigation included representatives from secondary and post-secondary education, business and industry, and government agencies. Focus groups and on-site interviews were conducted to obtain a sense of the local business and industry employment and training issues. Using the information obtained from the focus groups and interviews a survey was constructed and implemented to assess the training and employment needs of the biotechnology industry throughout Oregon. Using the information obtained from the data of the survey a DACUM process was used to further identify specific skill sets critical to industry's training needs. These skill sets assisted in the design of a transferable program and curriculum for more customized training experiences to include certificates and degrees.

Research found that the bioscience industry has some difficulty filling positions with appropriately trained individuals. Furthermore there was a strong interest for industry to maintain and cultivate a qualified bioscience technician workforce. The grant's survey indicated that some of the more notable current challenges in keeping a trained workforce are: (a) quality and affordable training, and (b) having a supply of skilled entry level workers. The research indicated there was no significant difference in the current and projected future challenges. Without some assistance the current challenges do not appear to lessen. This indicates a potential need for an NSF funded ATE center in addition to regional industry-specific training programs.

Focus groups strongly endorsed movement toward a science (biology and/or chemistry) technician two-year degree. In addition, a majority of the survey respondents showed a strong interest in hiring trained employees with a science-based technician skill set. Important emphases were placed on technical skills involving safety, documentation of records, standard operating procedures, operation of instrumentation, basic chemistry and biology laboratory skills, and hazardous materials handling. In addition to the technical skills the nontechnical skills including reading, oral and written communication, and teamwork were cited as important. With the assistance of local academia and business and industry a potential transferable program was designed. Transferability between community colleges and universities creates a career pathway for technicians to redefine their opportunities within an organization, and is thusly of significant interest to employers. A transferable program has potential for articulation; however until actual program curricula are developed, a signed agreement is currently not possible. The agreement should include commitments by an advisory board, industry and academia for which collaboration is an integral part of the endeavor.

Through the joint leadership of academia and the Oregon Bioscience Association an NSF funded Advanced Technology Education center would provide the avenue for the collaboration of standards, dissemination of information, development of program training curricula, and assistance with career pathways for the bioscience industry sectors. An ATE center could provide assistance in the development of career pathways that begin early on in the education of future Oregonians and strengthen the workforce.

Based on the findings of this study, the researchers recommend the implementation of: (1) a transferable science technician training program within the Willamette Valley, and (2) an NSF funded ATE Center of Excellence in Portland Oregon. This center should have joint leadership of the Oregon Bioscience Association and academia. Oregon community colleges should seek private, state and federal funding to accomplish these objectives, thus ensuring Oregon remains relevant within the international bioscience market and can meet the changing training needs of Oregon's workforce. For a more comprehensive view of the research design, findings, and conclusions, please see the full report.

Exploring Biotechnology: A Pathway to Prosperity in Rural and Urban Oregon?

Introduction

During the past two decades, new technology and the globalization of business and industry have resulted in postsecondary education becoming a central facet of workforce development. As international competition increases, industry has turned to community colleges to develop programs that increase the skill level of the professional technical workforce. Federal and state governments have invested substantially in community colleges to provide technical education (Bradley, 2006). Community colleges have provided training in high performance occupations (Jacobs & Voorhees, 2006) such as the bioscience technician, thus providing training necessary for the nation to strengthen its competitiveness in the global economy (Gruber, 2000). However, equipping the bioscience business and industry workforce will require not only the involvement of the community college but also the collaboration of industry, academia, professional societies, and workforce organizations on activities that promote education and career development in training programs. Here we report on a project investigating the potential for an Advanced Technology Education (ATE) center and/or training program for bioscience technicians in Oregon.

Bioscience technicians conduct a variety of procedures, from simple laboratory techniques to complex research projects. Technicians also assist biological and medical scientists in laboratories. These technicians set up, operate, and maintain laboratory instruments and equipment, monitor experiments, make observations, perform calculations and record results. The bioscience technician may also analyze organic substances, such as blood, food, and drugs (Oregon Employment Department, 2013). A

National Science Foundation ATE regional center's main focus and goals would be to connect bioscience industries and educational institutions (community colleges, baccalaureate institutions, and high schools). A regional center in Oregon could improve and expand educational programs that prepare skilled technicians to work in the biosciences. A center can enhance training programs by creating a system for the sharing of information, providing cutting edge professional development for instructors, improving curriculum, and making use of current technologies in the biosciences (Bio-Link, n.d.).

Research Purpose and Objectives

Acknowledging that community colleges are the primary providers of technical training in the U.S., the research topic for this planning grant was designed to explore the potential for an Advanced Technology Education (ATE) Regional Center of Excellence in Biotechnology in Oregon's Willamette Valley at Linn-Benton Community College. This exploration led to the purpose of the study; which was to identify, examine, and analyze the occupational and workforce education and training needs for the Oregon biotechnology industry. With this purpose in mind, the study addressed the following objectives:

- Explore the geographic distribution of bioscience industry throughout Oregon, identify industry subsectors, and establish employment needs in aggregate and by subsector; identify common, portable skill competencies for biotechnicians in biopharmaceuticals, biomanufacturing, biomedical, and bioagriculture.

- Expose industry, secondary and higher education institutions to successful and replicable biotechnology programs and industry-academic partnerships from elsewhere in the U.S.
- Develop and formalize institutional alliances among regional community colleges, four-year institutions, secondary schools, corporations, industrial councils, and government agencies.
- Review and evaluate existing educational materials and develop program curricula that are interdisciplinary, competency-based, and occupationally verified.
- Design career pathways that identify clear educational steps on career paths matched to labor market demand and facilitate student transitions between high schools, community college, and four-year institutions.

The exploration of the first objective identified the following: (a) geographic location of potential partners in the Oregon bioscience industry, (b) current and long-term (5-10 year) occupational and workforce training needs, and (c) desired skill competencies for Oregon's biotechnician workforce. These findings provided focus and direction for the investigation's additional objectives. The second objective's research allowed the grant's investigative team to explore successful training programs throughout the U.S. The third objective established alliances among academia, industry, and government agencies. The fourth objective was completed through the development of a potential curriculum for a bioscience training program. The skill sets identified through the focus groups, in-depth interviews, survey data and a process for Developing A Curriculum (DACUM) were included in the development of the bioscience curriculum. Finally, the fifth objective of the planning grant designed a career pathway from the high school to the four-year institution.

Design of the Research

The purpose of this research was to identify, examine, and analyze occupational and workforce education and training needs for the Oregon biotechnology industry. There is a wide range of factors that affect a quality educated and trained workforce for the Oregon bioscience industry. These factors were examined through several methods. The methods used in this research consisted of the formation of an Advisory Board, focus group interviews, in-depth interviews, a survey of the industry, a DACUM process, and on-site and virtual program visitations.

Advisory Board

An advisory board was established to assist in guiding the research team in the grant's objectives. The advisory board consists of members of business and industry, post-secondary education, secondary education, and the Oregon Bioscience Association. The board is kept informed of the progress of the grant through the college's website and meetings.

Focus Groups

Employers and employees from Oregon's biosciences industry were invited to Linn-Benton Community College to have a meaningful conversation and explore: (a) current and future challenges in hiring and retaining employees, (b) solutions for workforce education and training, (c) the roles, skills, and responsibilities of the science technician, (d) the essential technical and non-technical skills needed for the bioscience technician, (e) the current practices for meeting training needs, and (f) what Linn-Benton Community College could do to assist in education and training.

In-Depth Interviews

The research team found that although the focus groups had highly productive conversations, very few of the invitees from business and industry could afford the time to participate. However, some companies indicated that if the research team went to their place of business, they would be able to participate. The project manager was able to hold in-depth interviews at on-site locations with employees from three separate companies and one university. The conversations explored the same questions and concerns as those of the focus groups.

The Survey

The manager of Linn-Benton Community College's Office of Institutional Research designed and administered the survey instrument. Input from the Oregon Bioscience Association, focus groups, and in-depth interviews was used in the survey design.

The Instrument

The survey instrument requested background and demographic information, such as the respondent's job title, company name and address, description of the company's industry or research area. The survey also addressed employer's difficulty in finding qualified people, adequacy of job preparation for entry level and incumbent workers, current and future challenges, types of training venues, types of technicians, and science-technician skill sets. Many of the skills mentioned by focus group participants were included in the skills list in this grant's survey instrument. This replication of data lends validity to the research which found pervasive agreement amongst the workforce skill sets. The survey instrument contained five questions related to demographics, 113 Likert scale rating statements, and ten open-ended questions.

Table 1: *Oregon Bioscience Survey Components*

Demographic information	Five questions related to the participant's company description, main function, address, and laboratory type.
Rated filling positions	Ten questions for rating difficulty in filling jobs.
Rated skill levels	Ten questions for rating adequacy of entry level and incumbent skill levels.
Rated challenges of industry	Eleven questions for rating challenges faced by industry in the current workforce and in the future workforce.
Rated training resources	Eight questions for rating how often certain types of training are used.
Rated the hiring of science technician	One question for rating the likelihood of hiring a science technician.
Rated skill sets	Seventy three questions for rating the desired/needed degree of proficiency of specified skill sets

The participants for the survey came from the Oregon BioScience Association (OBA) membership list, the Department of Agriculture, and other local business and industry. The target population consisted of those individuals who were sent surveys. The sample consisted of those participants who returned completed surveys.

Survey Dissemination and Data Collection Procedures

Data were collected using an electronic survey of bioscience business and industry participants in Oregon. The target population was contacted through email.

Individuals for the study volunteered; thus, making themselves available for participation in the research. The correspondence included directions for completing an electronic survey via the Internet. Follow up emails were sent to non-respondents encouraging their participation in the study.

DACUM Process

The DACUM is a facilitated analysis process that uses a panel of expert workers to identify and list duties and tasks related to a specific job. The process can be used for job analysis, occupational analysis, process analysis, functional analysis, and conceptual analysis. This process is an effective method of quickly determining the competencies, duties, and tasks that must be performed by persons employed in a given job or occupational area. The DACUM analysis can be used as a basis for curriculum development, student learning, training needs assessments, competency test development, and job descriptions.

Bioscience industry employees and employers formed the DACUM Panel. The panel worked with the guidance of the grant's project manager to develop the DACUM Research Chart. Brainstorming techniques were used to obtain the collective expertise and consensus of the panel members.

The DACUM Panel was guided through the following steps by the facilitator: (a) Orientation to DACUM, (b) overview of job or occupational areas, (c) identification of the duties (general areas of the job responsibility), (d) identification of specific tasks performed for each duty, (e) development of lists of general knowledge for skills, tools and equipment, (f) identification of worker behaviors and future trends/concerns, (g) review and refinement of duty and task statements, and (h) sequence duty and task statements.

On-site and Virtual Program Visitations

The principal and co-principal investigators of this grant made several on-site visitations of programs and attended ATE and BioLink conferences. On-site visitations proved valuable in the exploration of facilities and curriculum, as well as making connections with program personnel. Discussions with faculty were very important in gaining knowledge of program limitations, challenges, and innovations.

Virtual program visitations allowed the research team to assess and evaluate curriculum from a variety of programs. Because society is turning to the online forum to educate individuals about their programs, access to this information is abundant. Several bioscience programs and Advanced Technology Centers were investigated for potential models for such a program or center in Oregon.

Results

The results of this research include data from focus group interviews, in-depth interviews, a survey of the industry, a DACUM process, and on-site and virtual program visitations. Using the information obtained from the research data a potential training program and career pathways were designed.

Focus Group Interviews

For the first focus group interview, 17 individuals from 14 companies were invited. A total of eight individuals attended. The second focus group invited 11 individuals from eight companies. Two individuals from the same company attended as well as the grant's consultant from Portland Community College.

Focus group participants were asked to identify three to five major challenges or concerns they currently face in hiring, retaining, and advancing workers. Their responses included the following issues: (a) new generation of workers -- different attitude toward work often including expectations or a sense of entitlement, (b) retirements -- aging boomer generation, and (c) depending on the season; a preferred ratio of one technician to two principal scientists or, for the production area, twenty technicians to one principal scientist.

Participants were also asked about the challenges they expect to face in the next five to ten years. Two major concerns were indicated: (a) increased regulatory oversight and (b) increased automation. The bioscience industry is experiencing a dramatically increased regulatory environment. In addition, the advancement of automation such as pneumatics, electronics, and analytical instrumentation was cited. Both of these concerns will impact the bioscience workforce; both in numbers of employees and types of training.

A discussion of some possible solutions for addressing participant workforce education and training needs indicated a strong endorsement for a science (biology and/or chemistry) technology training program. Participants were very helpful in providing suggestions on program structure and curriculum development. Topics discussed for program design included: (a) a cohort model, (b) formalized apprenticeships, (c) strong ties with industry, (d) industry input in curriculum design, (e) parallel training for the faculty, (f) student advising and mentoring, (g) student connectivity with industry, and

(h) certification of students for hazardous materials response (i.e. Hazmat class). Furthermore, on the topic of program design, participants encouraged the grant's investigative group to emphasize to the student that this would be a specific technical degree that meets industry needs, not just a two-year degree.

Interviewees were asked to describe the essential technical skills needed for their science technician. The following skills stood out in the conversations:

- Handling of new and older instrumentation (i.e. use, calibration, and maintenance) such as balances, spectrophotometers, pH meters, etc.
- Adherence to standardized processes
- Characterization, analysis, and documentation of results
- Proper documentation of the process or procedure
- Preparation and transfer of solutions
- Measuring a group of unknowns against calibrated standards
- Basic biological and chemical lab processes
- Knowledge of the terminology associated with the job

In addition to the technical skills needed in their workplace, interviewees were also asked about the essential non-technical skills, or soft skills, for their industry positions. The characteristics and skills the focus groups preferred were: (a) critical-thinking and problem-solving, (b) documentation skills, (c) verbal and written communication skills, (d) team based collaborative problem-solving, (e) people who want to work, (f) a positive work ethic, (g) a sense of shared ownership for the work outcomes, (h) respect for employer, and (i) an unselfish interest in the overall business.

The focus groups provided a great deal of information with respect to their employment needs. However, as indicated earlier only a few companies were able to attend. Other companies were asked to join in the conversation and research by allowing on-site interviews. These interviews confirmed and added information from the focus groups.

In-Depth Interviews

One research institution (Oregon State University) and three Willamette Valley bioscience companies were visited by the grant's project manager. A total of fourteen employees were interviewed. These interviews included the same questions asked of the focus groups. The following major current and future training needs for hiring, retaining, and advancing workers were indicated:

- Analytical instrumentation training (including high-performance liquid chromatography, gas chromatography, ultraviolet and infrared spectroscopy, and mass spectrometry)
- Communication skills, including technical writing
- Microbiology and chemistry laboratory skills
- Analytical skills
- Cell culture and sterile processing
- Data collection, analysis and statistical skills
- Genome enabled research
- Skills to drive research forward
- Work collaboratively
- Current good manufacturing practices (CGMP)

- Good laboratory practices (GLP)
- Laboratory information management systems (LIMS)
- Technical writing and laboratory notebook documentation skills
- Sterile technique
- Computer skills
- Ability to ask questions; not afraid to admit mistakes

The on-site visitations and focus groups assisted in the design of a survey to further investigate the needs of the bioscience industry in Oregon. The results of the survey are provided in the next section.

The Survey

This grant examined many facets of the bioscience industry in Oregon using a survey instrument. The respondents to the survey were asked to describe their industry or research area as well as rate expectations, challenges facing entry level and future employees, and a desired set of employee skills.

The methods used in the survey included collecting descriptive data and ratings using the opinions or perspectives of participants. The analysis of the survey data used descriptive and inferential statistics to describe, analyze, and evaluate the relationships among the perceptions of the participants. The associational statistic's primary purpose was not to determine causes and effects but rather to identify and investigate relationships.

The quantitative raw data collected from the survey responses was analyzed using the Statistical Packages for the Social Sciences (SPSS). Furthermore, the open-ended questions presented an avenue for participants to provide greater insight into the biosciences business and industry in the state of Oregon.

Participant Sampling and Response Rate

An invitation to participate in the current study was extended to 618 companies throughout the state of Oregon. Companies from three regions of Oregon participated in the survey; Portland Metro Area (PM), Willamette Valley (WV), and Central Oregon (CO). See Table 2 below for a listing of the participants' cities and associated regions. Individuals from 79 companies agreed to participate, yielding a company response rate of 13%. Surveys were sent to 2,059 employees. There were 143 survey respondents, yielding a response rate of 7% for individual participants. However, not all of these respondents completed the entire survey. There were 18 companies that had more than one participant. No follow-up was undertaken to check for non-response bias.

Table 2: *Regions of Oregon Associated with Bioscience Survey Participants*
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Region	Portland Metro Area	Willamette Valley	Central Oregon
Participating Cities	Beaverton, Camas, Forest Grove, Hillsboro, Lake Oswego, Portland, Tigard, Tualatin, Vancouver, Wilsonville	Albany, Corvallis, Creswell, Eugene, Philomath, McMinnville, Salem	Bend, Redmond

The exploration of the geographic distribution of bioscience industry respondents to the survey throughout Oregon found 97 in the Portland Metropolitan area, 40 in the Willamette Valley and 6 from Central Oregon. Of the 40 respondents in the Willamette Valley most are located in the Corvallis area, near Linn-Benton Community College.

The bioscience industry has a variety of science-related objectives. The survey participants were asked to describe the area of bioscience that best described their industry or research area, see Figure 1. Of the 142 respondents, 45.1% indicated medical device, 15.5% bio-tech, 9.2% bio-agricultural, 4.2% pharmaceutical, 2.8% biomanufacturing, 1.4% chemical, and 21.8% other. Participants that indicated “other” as a response were asked to specify. This specification included education, consulting, research, and capital venture among the answers.

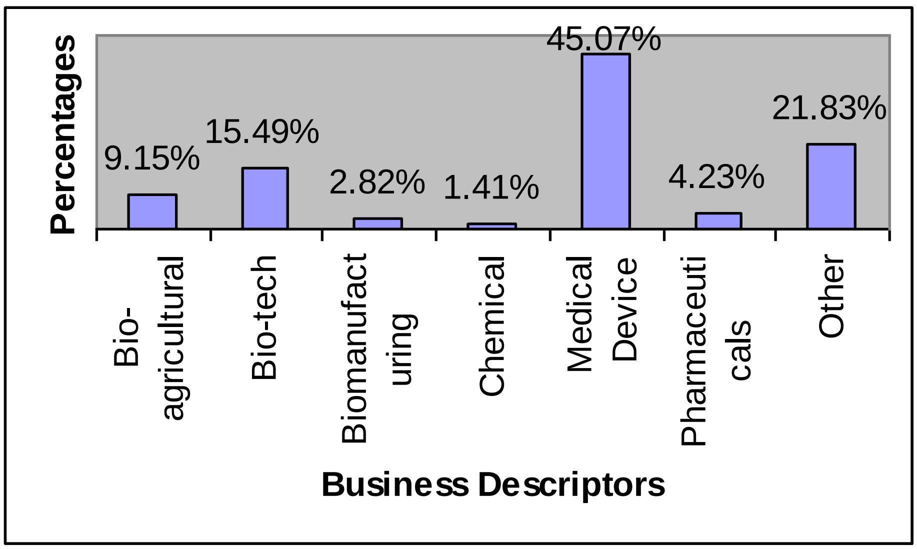

Figure 1: Percentage of types of bioscience businesses

To further investigate the bioscience industry in Oregon the survey asked how participants viewed the main functions of their company, see Figure 2. The participants were asked to mark all of the functions that applied. Of the 143 respondents, 64.3% indicated research, 58.7% production-manufacturing, 34.3% quality control, 32.2% quality assurance, 26.6% testing, 21.7% inspection, 18.2% materials control, 16.1% facilities maintenance, 16.1% training, 9.1% formulation, 4.9% investment, and 11.9% other functions. Participants that indicated “other” as a response were asked to specify.

This specification included regulatory affairs, research and development, recruitment, and investment among the answers.

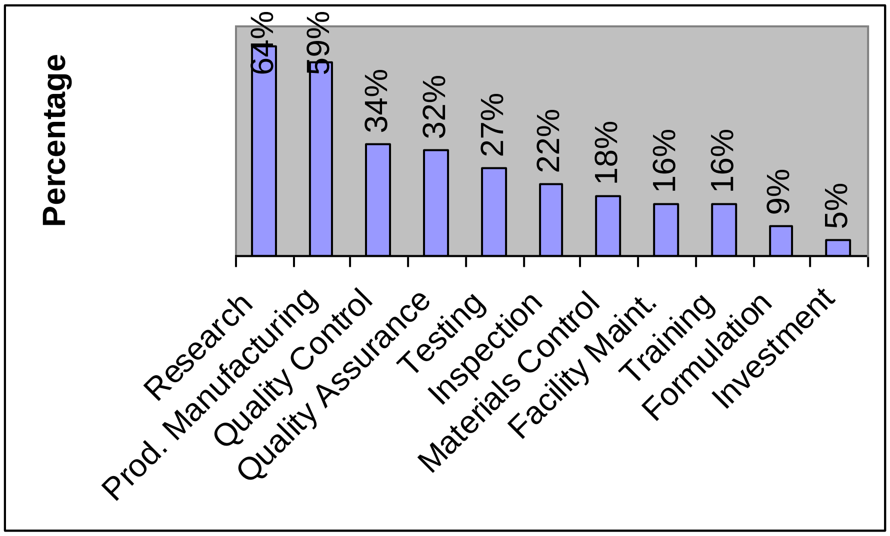

Figure 2: Percentages of bioscience business' main functions

Additional information from the survey data assisted in the identification of the type of bioscience laboratory used by the companies. The participants were asked to select a particular type of laboratory within their companies and to mark all that applied, see Figure 3. Of the 143 respondents, 46.2% selected manufacturing, 27.3% biology, 22.4% molecular biology, 21.0% biochemistry, 21.0% clean room, 18.2% microbiology, 13.3% organic, 11.2% immunology, 9.1% physiology, 2.1% food quality, and 16.1% other. Participants were not asked to be specific when selecting "other".

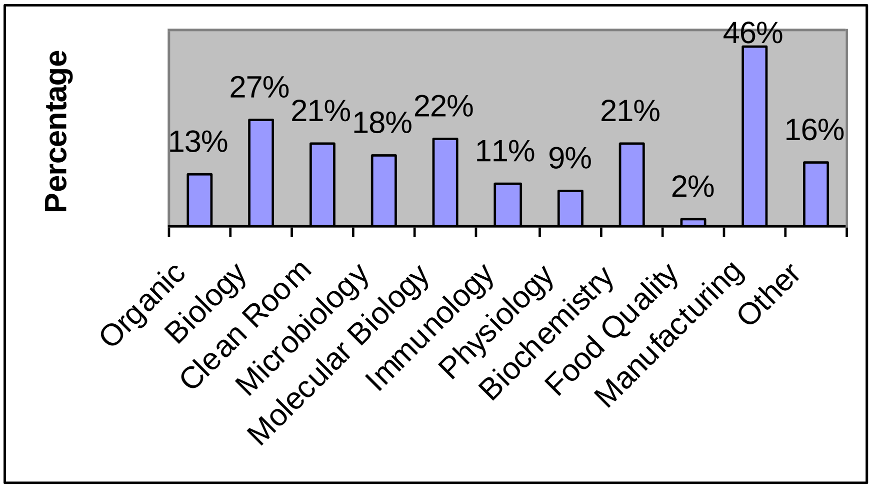

Figure 3: Percentages of bioscience business' laboratories

The participants of the survey were requested to indicate a level of difficulty in filling specific types of positions. The three positions noteworthy to this research study were identified as: (a) the production workforce, (b) science or engineering professional, and (c) process or laboratory technicians. The collected data from the 83 respondents indicated that 54% had difficulty in filling production workforce jobs, 72% had difficulty in finding science or engineering professionals, and 53% had difficulty in filling positions for process or laboratory technicians.

A comparison between entry and incumbent worker's level of adequacy in the performance of ten skills listed in the survey was statistically analyzed using the means and standard deviations of the ratings of the 74 respondents. Participants were asked to rate the skill level on a four point Likert scale. The Likert scale had four options (1 = not at all adequate, 2 = somewhat adequate, 3 = mostly adequate, and 4 = very adequate). The results of the data analysis indicated that the participants rated the entry level worker's skills as somewhat to mostly adequate, see Table 3. The study further indicated that the incumbent worker's skills were rated higher for all skills. To further study the comparison between participant ratings for the entry level worker with the ratings for the incumbent worker, a t-test of statistical analysis was applied. The null hypothesis (H_o) was that there were no significant differences in ratings of the participants for the entry level workers as compared with the incumbent workers. The alternative hypothesis (H_1) was that significant differences were indicated. A summary of the results for each of the skill ratings is presented in Table 3. It is apparent that at the $p < 0.01$ level of significance the null hypothesis should be rejected and all skill ratings show a significant difference between the entry level and the incumbent workers. This indicates the potential for the community college to become involved in the education and training of the bioscience workforce in order to raise the skills of the entry level employee. It may be possible that the difference in skill level adequacy of the entry level worker and the incumbent worker can become more closely aligned through a training program with a strong partnership between the bioscience industry and academia. Raising the skill levels of entry level employees may allow industry to focus on business rather than training. Ultimately an Advanced Technology Education (ATE) Center may have a role in assisting the building of partnerships within and between academia and industry.

Table 3: *Mean Ratings and T-Tests for Significant Differences in Entry Level and Incumbent Skill Level Ratings by Bioscience Participants*

Skills	Entry Level Mean (SD)	Incumbent Mean(SD)	Standard Error Mean	t	df	Sig (2-tailed)
Technical skills	2.41 (0.775)	3.04 (0.730)	0.087	-7.277	73	0.000*
Technology skills	2.75 (0.746)	3.07 (0.699)	0.076	-4.194	71	0.000*
Problem-solving and critical thinking	2.42 (0.828)	2.97 (0.721)	0.082	-6.760	73	0.000 *
Listening	2.62 (0.659)	2.88 (0.622)	0.068	-3.847	72	0.000 *
Speaking	2.35 (0.730)	2.80 (0.740)	0.072	-6.163	73	0.000 *
Math	2.67 (0.721)	3.20 (0.719)	0.087	-6.195	68	0.000 *
Reading	2.90 (0.720)	3.21 (0.695)	0.077	-4.044	70	0.000 *
Writing	2.46 (0.867)	2.80 (0.867)	0.076	-4.367	69	0.000 *
Team collaboration	2.80 (0.632)	3.06 (0.820)	0.087	-3.007	68	0.004 *
Professionalism,	2.79 (0.636)	3.16 (0.614)	0.078	-4.706	67	0.000 *

*Significant at the 0.01 level (2-tailed)
N = 75

This research also investigated the challenges faced by the bioscience industry in obtaining and keeping a trained workforce. Current and future (5 to 10 years from now) bioscience training needs were investigated through the survey. Participants expressed their opinions of the degree of challenges they faced with the use of a Likert scale. The Likert scale had five options, ranging from 1 (not at all a challenge) to 5 (very much a challenge), with 3 as somewhat a challenge. Sixty-five respondents indicated that currently it is at least somewhat of a challenge to: (a) obtain an adequate supply of skilled workers, (b) provide training to keep skilled workers, (c) afford training to keep a skilled workforce, (d) find time to devote to training, (e) get the next generation interested in the bioscience career, and (f) implement training. Respondents felt that in the next 5 to 10 years challenges will increase in the following areas: (a) adequate supply of skilled workers, (b) next generation's interest in the bioscience career, (c) skilled employees leaving the workforce, (d) quality of life in the region, and (e) affordable living in the region, see Table 4. To further study the comparison between respondent ratings for current challenges to those of a future workforce (5 to 10 years), a t-test of statistical analysis was applied. The null hypothesis (H_o) was that there were no significant differences between the ratings of the respondents for current and future challenges in obtaining and keeping a trained workforce. The alternative hypothesis (H_1) was that significant differences were indicated. A summary of the results for each of the challenge's ratings is presented in Table 4. It is apparent that at the $p < 0.01$ level of significance the respondents felt they would be facing increased challenges in: (a) workers leaving the workforce, (b) quality of life in the area, and (c) affordability of living in the area. There were no significant differences in the opinions of the respondents between current and future challenges for: (a) having an adequate supply of skilled workers, (b) availability of training, (c) affordability of training, (d) time for training, (e) getting the next generation interested in the biosciences careers, and (f) the capacity to implement training. The lack of significant differences in the perspectives of the respondents may indicate an inability to improve the challenging issues currently being faced by the industry without some type of intervention. These current challenges appear to the respondents as continuing without improvement in the future. Of particular concern are the challenges of the affordability and time for training to keep a skilled workforce. Thus, an ATE center and a bioscience training program may be able to assist in alleviating at least to some degree some of the future workforce challenges of the bioscience industry.

Table 4: *Mean Ratings and T-Tests for Significant Differences in Challenges in Getting and Keeping a Trained Workforce by Bioscience Participants*

Challenges	Current Mean (SD)	5-10 years Mean (SD)	Standard Error Mean	t	df	Sig (2-tailed)
Adequate supply of skilled workers	2.94 (1.27)	2.97 (1.21)	0.104	-0.287	66	0.775
Availability of the training to keep skilled workforce	3.00 (1.01)	2.91 (1.05)	0.099	0.948	63	0.347
Affordability of training to keep skilled workforce	3.27 (1.17)	3.22 (1.20)	0.114	0.417	62	0.678
Having time for training to keep skilled workforce	3.41 (1.09)	3.34 (1.13)	0.120	0.522	63	0.603
Getting the next generation into the pipeline	2.83 (1.06)	2.94 (1.05)	0.097	-1.123	63	0.266
Workers leaving the workforce	2.23 (1.09)	2.53 (1.11)	0.116	-2.634	61	0.011*
Quality of life in the region	1.92 (1.11)	2.14 (1.19)	0.077	-2.903	62	0.005*
Affordability of living in the region	2.32 (1.07)	2.56 (1.17)	0.064	-3.795	61	0.000*
Capacity to implement training needs	2.98 (1.11)	2.79 (1.06)	0.097	1.993	61	0.051

* Significant at the 0.01 level (2-tailed)
N = 65

Participants were asked to speculate on the number of the science-based technician positions they would fill in the next three to five years. Of the 55 respondents, 11% indicated more than 10 technicians, 44% indicated less than 10, and 45% felt they were uncertain at this time, see Figure 4.

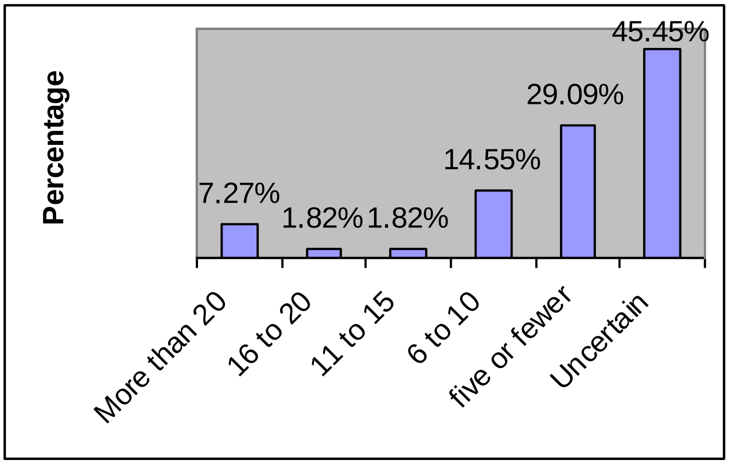

Figure 4: Percentage of speculated hiring of science technicians

Recognizing that varying numbers of respondents answered the survey questions the following results were obtained. Only 11% of the 70 respondents indicated they required an industry-specific certificate and 27% indicated they required industry-specific training for entry level employees. However, when asked about to what extent the participants had trouble finding entry level workers with the required certificates, approximately 55% of the 45 respondents had little to no difficulty, but 44% had some to much difficulty. This difficulty in finding entry level workers with required certificates may be why only some industry requires such certification. The survey found that approximately 42% of the 48 respondents had little to no difficulty in finding entry level workers with industry-specific training and 58% had some to much difficulty. The difficulty in finding entry level employees with appropriate training or certifications may be somewhat alleviated for those companies desiring these requirements if access to such training was made available. Whether or not industry-specific training or certifications would be required by employers in Oregon's bioscience industry requires further study. However, an ATE center could provide a venue for the collaboration of both skill standards and certification requirements for the industry.

Analysis of the data for the three separate regions (Willamette Valley, Portland Metro, and Central Oregon) provided some further insight for certificates and industry specific training needs. Of the 51 respondents from the Portland Metro area 12% indicated they required an industry-specific certificate. Two percent of the 15 Willamette Valley respondents and none of the four Central Oregon respondents required industry-specific certification. The research also indicated that 34% of the 65 respondents from the Portland Metro area, 63% of the 11 Willamette Valley respondents, and 50% of the two Central Oregon respondents had some degree of difficulty in finding entry level workers with the required certification. Furthermore 19% of the 48 respondents from the Portland Metro area had a requirement for industry-specific training for entry level employees. Fifty three percent of the 15 respondents from the Willamette Valley and 25% of the four respondents from Central Oregon required industry-specific training. Fifty percent of the 34 Portland Metro area respondents, 76% of the 13 Willamette Valley respondents, and 100% of the one Central Valley respondent had some degree of difficulty in finding entry level workers with industry-specific training.   The difficulty in finding entry level employees with appropriate training or certifications may be somewhat alleviated for those companies desiring these requirements if access to such training was made available. Although the Willamette Valley does not have as much bioscience industry as the Portland Metro area it appears that a program in the local area could assist in providing the necessary workforce training. An ATE center in Oregon could facilitate the collaboration of the local businesses, community colleges, and universities in the design of the educational program providing the necessary certifications and bioscience training.

Further evaluation of how often the participants used specific types of training was conducted through the survey research. Table 5 indicates a relatively high number of the 71 respondents use informal and formal on-the-job-training for their entry level and incumbent employees. In addition, a relatively large number of the respondents use online instruction, classroom training, formal education, and sometimes training from their professional associations. This may be due to a lack of a locally available training program or the inability of employees to be trained other than on-the-job. This implies a gap may exist in the training needs of the industry. Community colleges could assist in filling this gap through jointly (industry and academia) developed curricula for specific skills, certificates, and/or degrees.

Table 5: *Percentage of Bioscience Participants Using Specific Types of Training*

Training Resources	Very Often	Often	Sometimes	Never
Informal On-the-Job Training	47.9%	31.0%	16.9%	4.2%
Formal On-the-Job Training	43.7%	25.4%	22.5%	8.5%
Classroom Training away from Employee Stations	12.9%	22.9%	50.0%	14.3%
Self-paced Online Training	11.4%	22.9%	41.4%	24.3%
Formal Education (Certificate or Degree) with Partner Institutions	4.3%	11.4%	47.1%	37.1%
Internship Programs	6.2%	12.3%	36.9%	44.6%
Oregon Bioscience Association	0.0%	26.6%	39.1%	34.4%
Other Industry Associations	1.6%	6.4%	54.0%	38.1%

This study extended its research beyond employment and training needs of the bioscience industry to specific qualifications of the bioscience technician. Forty nine percent of the 55 respondents had some degree of difficulty finding qualified science-based technicians in their area. Fifty percent of the respondents were somewhat or less satisfied with the education and training of their newly hired science-related technicians. The degree of satisfaction of industry for its new hires could be improved with a program that specifically addresses the training deficiencies.

Analysis of the data by region (Portland Metro, Willamette Valley, and Central Oregon) indicated that of the 28 respondents from the Portland Metro area 54% had some degree of difficulty finding qualified science technicians. Thirty-seven percent of the 24 Willamette Valley respondents and 100% of the three Central Oregon respondents had difficulty in finding qualified science-based technicians. Further analysis of the survey data indicated that 54% of the 28 Portland Metro area respondents, 37% of the 24 Willamette Valley respondents, and 33% of the three Central Oregon respondents were somewhat or less satisfied with the education and training of their newly hired science technicians. Bioscience training programs in the Portland Metro and Willamette Valley could assist in meeting the education and training needs of the entry level workforce in the biosciences. Although the Portland Metro area has a bioscience training program at Portland Community College, an ATE center could provide further collaboration with industry for such topics as marketing of the program, internships, and curriculum development.

Specifically addressing the "qualified" science technician, the survey provided a description of the hypothetically trained individual. Survey participants were asked to consider the following description of science technicians when answering subsequent questions:

> Science technicians use the principles and theories of science and mathematics to assist in research and development and to help invent and improve products and processes. However, their jobs are more practically oriented than those of scientists. Technicians set up, operate, and maintain laboratory instruments, monitor experiments, make observations, calculate and record results, and often develop conclusions. They must keep detailed logs of all of their work. Those who perform production work monitor manufacturing processes and may ensure quality by testing products for proper proportions of ingredients, for purity, or for strength and durability.

When asked if their company would consider hiring the science-based technician described above, 86% of the 57 respondents indicated they would. These findings provide evidence that quality science-based technician education programs could supply the necessary qualifications and characteristics of a sustainable bioscience workforce. This supply of more qualified entry level technicians should improve the satisfaction of the industry with its newly hired employees.

The survey data showed that 58% of the 55 respondents employed process technicians, 44% employed manufacturing technicians, and 81% employed laboratory technicians. Participants were asked to rate specific technical science-based laboratory or process technician skills with which an entry level employee should be proficient. The level of proficiency for skills were rated using a six point Likert scale (not sure, not important, useful but not essential, somewhat essential, must possess some skill, and essential proficiency). Table 6 illustrates, by geographic region [Portland Metro Area (PM), Willamette Valley (WV), and Central Oregon (CO)] the technical skills (some to essential) a majority of respondents from each region (X) felt entry level workers must possess in order to perform the daily tasks. While many skills are consistent across the regions, it is clear that the Willamette Valley and Central Oregon regions differ somewhat from the Portland Metro area. This indicates the importance for community college training program faculty to collaborate with local industry to ensure the specific training needs of the employers are met. If training programs do not meet these needs, the employability of students and the sustainability of the program will become adversely impacted.

Table 6: *Important Technical Skills for Entry Level Technicians Relative to the Geographic Region.*

Skills	PM	WV	CO
Appropriately clean glassware, dispose of waste, and maintain reagent integrity	X	X	X
Set up equipment, monitor, and complete reactions	X	X	X
Collect, record and analyze data for reactions	X	X	X
Identify and troubleshoot erroneous results	X	X	X
Use appropriate filtration, titration, and pipetting techniques	X	X	X
Perform basic separation techniques			X
Perform test/assays: chemical, biological, clinical, environmental, robotic, mechanical	X	X	X
Operate centrifuges, pH meters, or spectrophotometers	X	X	
Maintain, operate, and troubleshoot laboratory instruments		X	X
Maintain, monitor, and correct for temperatures, pressures, levels and flow of equipment			X
Maintain a small or large inventory of chemical compounds	X	X	X
Maintain inventory of lab supplies and order supplies and reagents as needed	X	X	X
Date, label and store supplies and reagents	X	X	X
Maintain and store manufactured products inventory			
Monitor physical properties of reagents, buffers, media and solutions		X	X
Determine the acceptability and optimum conditions of reagents for tests	X	X	X
Calculate, prepare, and execute dilution’s series	X	X	X
Package, handle and ship biological materials		X	
Prepare and dispense stock reagents, buffers, media and solutions	X	X	X
Sterilize reagents, buffers, media and solutions		X	X
Obtain, label, and/or assess acceptability of specimen		X	X
Request tests and match request to test sample			X
Prepare test subjects for sampling		X	X
Prepare sample for testing		X	X
Sterile fill, lycophilization and packaging			
DNA electrophoreses		X	
Apply artificial insemination techniques			
Apply plant disease control techniques			
Apply plant materials principles		X	
Apply planting or transplanting techniques		X	
Apply soil science principles		X	
Conduct vivisection			
Identify tree and plant characteristics			
Inspect fields or forests to detect plant diseases, pest infestations or noxious weeds			
Recognize plant disease			
Recognize tree and forest plant species			
Use herbicides and pesticides			

The majority of survey respondents from all of the regions rated the following skills as “essential and extremely important” to the bioscience technician’s daily tasks: (a) collect, record, and analyze data for reactions, (b) use appropriate filtration, titration, and pipeting techniques, (c) identify and troubleshoot erroneous results, (d) date, label and store supplies and reagents, and (e) prepare and dispense stock reagents, buffers, media and solutions.

In addition to the technical skills the non-technical bioscience laboratory or process technician job skills were also researched as to the degree to which an entry level employee should be proficient. Table 7 illustrates by geographic region [Portland Metro Area (PM), Willamette Valley (WV), and Central Oregon (CO)] the non-technical skills (some to essential) a majority of respondents (X) felt entry level workers must possess in order to perform the daily tasks. There were only three differences between the Portland Metro area and Willamette Valley respondent ratings regarding the non-technical skill sets. However, these differences provide even further evidence for specifically designed training programs for local business and industry.

Table 7: *Important Non-Technical Skills for Entry Level Technicians Relative to the Geographic Region.*

Skills	PM	WV	CO
Use appropriate laboratory safe practices	X	X	X
Comprehend technical vocabulary, follow protocols, and maintain a laboratory notebook	X	X	X
Follow, write, update, and report Standard operating procedures (SOP)	X	X	X
Comply with FDA and cGOM Regulations	X		X
Manage process monitoring/process review documentation	X		X
Maintains, troubleshoots and initiates corrective action to meet production schedules	X		X
Perform basic mathematical skills	X	X	X
Have basic computer skills-Microsoft office competent	X	X	X
Maintain records/documentation of procedures	X	X	X
Obtain and comprehend protocol, test procedure, SOP’s	X	X	X
Write or update protocols, SOP’s, manuals, reports, and technical summaries	X	X	X
Understand and be able to use Kaiser Principles/Lean Manufacturing			X
Understand and commit to quality control, and /or continuous improvement	X	X	X
Have public speaking skills	X	X	X
Properly interact with colleagues, supervisors and clients	X	X	X
Have a professional workplace ethic	X	X	X
Have good problem-solving critical thinking skills	X	X	X
Able to cope with rapid change and be an active “learner”	X	X	X
Collaborate with others in the workplace	X	X	X
Have leadership skills		X	X
Work as a team-player and builder	X	X	X
Work well with a diverse group of individuals	X	X	X
Be thorough and conscientious	X	X	X
Take initiative	X	X	X
Accept and use constructive criticism	X	X	X
Be reliable-timeliness, attendance	X	X	X
Projects understanding of an commitment to the company mission	X	X	X
Respect confidentiality of the business environment	X	X	X

Safety skills for science-based technicians were also researched as to the degree to which an entry level employee should be proficient. Table 8 illustrates by geographic region [Portland Metro Area (PM), Willamette Valley (WV), and Central Oregon (CO)] the safety skills (some to essential) a majority of respondents (X) felt entry level workers must possess in order to perform the daily tasks. There were no differences between the majorities of respondents of the three regions of Oregon with respect to the safety skill sets. All of the respondents felt each of the skill sets, with the exception of working with heavy machinery, were very important for the entry level employee.

Table 8: *Important Safety Skills for Entry Level Technicians Relative to the Geographic Region.*

Skills	PM	WV	CO
Follow and enforce effective safety procedures, guidelines, and plans	X	X	X
Observe, identify, and document safe practices	X	X	X
Meticulously follow directions both written and oral	X	X	X
Process and dispose of waste material as per guidelines	X	X	X
Comply with government and/or accreditation regulations	X	X	X
Follow universal safety precautions	X	X	X
Follow safe heavy machinery protocols			
Use appropriate safety precautions to handle hazardous biological/chemical materials	X	X	X

The DACUM Process

Eleven individuals from industry were invited to the DACUM meeting, of which four participated. One advisory board member and the principal investigator (PI) were observers. Participants provided their perspectives of the science laboratory technician position. The research chart that resulted from the DACUM analysis is a detailed and graphic portrayal of the skills, abilities, competencies, and duties involved in the position of a science technician. The results or chart of the DACUM process outcomes are located in Table 9. The DACUM chart and survey data provided skill sets used to assist in the design of a potential bioscience training program. However, before these specific skill sets could be used program coursework had to be identified. Exploring other regional centers and their associated programs through on-site and virtual visitations provided the potential program's coursework foundation.

Table 9: *DACUM Research Chart for Laboratory Technicians*

DACUM Chart: Laboratory Technician

Safety/Continuous Improvement throughout All Duties/Tasks (A-F)

Duty						
A **Prepare Procedures**	A1 Review SOPs (standard operating procedures)	A2 Review safety and PPE requirements	A3 Check sample expiration dates	A4 Check reagent expiration dates	A5 Check reagent handling requirements	
	A6 Prepare chemical reagents	A7 Receive laboratory samples *	A8 Prepare laboratory samples *	A9 Prepare testing mediums	*Sample types may include: Biological, Chemical, Medical, Microbial	
B **Prepare Daily Work**	B1 Determine work priorities	B2 Check work instructions/wor k packets/SOPs	B3 Assemble chemical supplies	B4 Assemble analytical equipment	B5 Inspect lab equipment and instrument	
C **Perform Procedures**	C1 Follow SOP or batch record	C2 Apply quality control protocols	C3 Conduct laboratory procedures	C4 Document time and materials used	C5 Document laboratory procedures	C6 Store and/or segregate materials
	C7 Track and transact product flow	C8 Return, archive or dispose of samples and waste	C9 Participate in continuous improvement activities	C10 Troubleshoot equipment functioning		
D **Evaluate, Document & Communicate Results**	D1 Analyze data for appropriateness	D2 Evaluate validity of results	D3 Document results, mistakes and deviations	D4 Prepare results reports		
	D5 Prepare report summaries	D6 Communicate results (oral, written, electronic)	D7 Transfer or transport results	D 8 Transfer or transport information		
E **Control Inventory**	E1 Take supply inventory	E2 Monitor inventory expiration dates/maintain FIFO	E3 Follow proper procedures for new chemicals	E4 Order stock supply inventory	E5 Check/review MSDS	E6 Properly store stock inventory

F **Maintain Equipment and Facility**	F1 Clean and maintain equipment	F2 Maintain equipment logs	F3 Conduct general work area housekeeping	F4 Troubleshoot equipment function	F5 Calibrate lab instruments

<u>Knowledge, Skills and Abilities</u>

- Ability to listen
- Communication of ideas peer to peer, in meetings or small groups, and up the organizational structure
- Ability to speak up, disagree
- Good oral, written, electronic communication
- Ability to deal with change
- Adaptability and flexibility
- Understanding of continuous improvement
- Problem solving
- Trouble-shooting
- Ability to ask questions
- Time management/setting priorities/efficient use of time
- Writing skills and proper grammar
- Willing to be cross-trained
- Ability to multi-task
- Ability to focus when necessary
- Ability to work with minimal supervision
- Understand and maintain confidentiality
- Respect proprietary information, materials
- Computer skills, e.g. Excel, pivot tables, macros, word processing, presentation
- Set work priorities with supervision
- Basic chemistry, periodic table, atomic weights, chemical reactions, wet chemistry, molarity, normality
- Understanding of pH/acids and bases
- Bench chemistry skills, e.g. using mechanical and glass pipettes, measuring flasks, bringing something to volume, meniscus, quantitative transfers, titration, dilutions, buffer solutions, extractions, electrophoresis
- Use of analytical balances
- Understand/Perform aseptic technique
- Use of autoclaves
- Preventing cross-contamination
- Lab housekeeping, e.g. clean glassware, work area, clean hood filters
- Use of fume and laminar flow hoods
- Basic understanding of microorganisms,
- Collect samples, e.g. water and swab samples
- Plating samples and reading the plates
- Contribute to developing test methods
- Technical writing skills
- Recording mistakes/failures
- Follow written procedures
- Basic math skills: e.g. averages, standard deviation, rounding, mean/median, basic statistics, units of measure, dry/wet volume, multiplication, division, significant figures
- Understand a calibration curve and comparing a known to an unknown
- Trigonometry (nice to know/not required)
- Regression curve
- Principle of logarithms
- Basic knowledge and awareness of radioactivity/radiation safety
- Laser safety
- Follow SOPs
- Keep an accurate inventory, e.g. recording accuracy, transaction accuracy, stock room management
- Adhere to waste management policies and procedures
- Ability to prioritize in a challenging environment

Future Trends

- Increased regulation
- Increased testing and data retention
- Increased automation
- Blend of mechatronics and lab technology
- More computer-based systems, e.g. virtual storage
- Lean Manufacturing
- Reliance on employees with multiple skills (fewer employees = need for greater efficiency

Worker Behaviors

- Ethical behavior
- Respect for confidentiality
- Ability to take responsibility for, and learn from, mistakes
- Willingness to record mistakes/failures
- Willingness to listen
- Willingness to learn/teach-ability
- Adaptable and flexible
- Multi-task but know personal limits
- Attention to detail
- Maintain personal and work boundaries/expectations
- Professional comportment
- Punctuality
- Take initiative – see what needs to be done and do it
- Attention to detail
- Good judgment
- Work safely, follow safety procedures

Acronyms/Terms

- GC (Gas Chromatograph)
- TEM (Transmission Electron Microscopy
- HPLC (High-performance Liquid Chromatography)
- FPLC (Fast Protein Liquid Chromatography)
- IR (Infrared) spectrophotometers
- UV/VIS (Ultra Violet/visible spectrum) spectrophotometers
- OES (Optical Emission Spectrometry)
- SIE (Specific Ion Electrode)
- OSHA (Occupational Safety and Health Administration)
- PPE (Personal Protective Equipment)
- FDA (Food and Drug Administration
- GLP (Good Lab Practices)
- PPE (Personal Protective Equipment)
- ASTM (American Society for Testing and Materials)
- SOP (Standard Operating Procedure)
- ISO (International Organization for Standardization)
- MSDS (Material Safety Data Sheet)
- USDA (United States Department of Agriculture)
- ERP (Enterprise Resource Planning)
- Internships and Cooperative Work Experience (CWE)

Tools and Equipment

- Personal Protective Equipment
- Atomic Absorption
- Confocal microscopy
- Interstitial Gas Analyzer
- Cytometers
- Electrophoresis
- Optical Emission Spectrometry
- Scales (basic and analytical)
- Gas Chromatograph
- Transmission Electron Microscopy
- High-performance Liquid Chromatography
- Fast Protein Liquid Chromatography
- Infrared spectrophotometers

• pH meters • Mass spectrometry • SIE (Specific Ion Electrode	• UV/VIS spectrophotometers

Additional Skills, Attributes, Equipment, Lab Practices:

Learn attributes of analytical methods:
1. precision
2. accuracy
3. robustness
4. reproducibility
5. linearity

Learn method limitations:
1. dilution errors
2. equipment errors
3. deterministic errors
4. calculation errors
5. measurement errors
6. additive errors
7. multiplicative errors

Learn equipment limitations:
1. limit of detection
2. limit of quantitation (highest and lowest)
3. optimization of detection
4. linearity
5. precision

Learn good lab practices;:
1. prevent contamination
2. use clean glass wares
3. learn to detect contaminations
4. learn to detect errors
5. use calibrated equipment

Learn good documentation practices:
1. legible writing
2. clean strike out and rewrite
3. initial and date records, remarks
4. note down other observations which may help later to detect errors, etc.
5. do not over write
6. note date and time
7. keep a personal lab book
8. no use of loose papers for data recording
9. keep records clean
10. prevent records from getting wet
11. make sure records are permanent
12. strike out unused area in lab book

On-site and Virtual and Program and Conference Visitations

The PI and Co-PI's attended the ATE conferences held in Washington DC in 2010 and 2011. These conferences were primarily information gathering expeditions. Networking and identification of key contacts from various ATE centers and BioTech programs in various parts of the U.S. were accomplished. The PI and Co-PI also attended the Bio-Link Conference in Berkeley, CA in 2011. This conference was used to gain information about Bio-Link and make connections with other program facilitators. Bio-Link is a national ATE center whose mission is to "strengthen and expand biotechnology education at community and technical colleges" (Johnson, 2013). Bio-Link program goals are to: (a) increase and diversify the technician workforce, (b) meet industry's increasing demand for trained technicians, (c) partner with industry to ensure appropriate and sustainable education and training for the bioscience workforce, and (d) demonstrate a commitment to ongoing program evaluation (Bio-Link, n.d.).

The PI and Co-PI made a program visitation to Portland Community College-Rock Creek Campus biotechnology training program. This visitation provided insight with respect to curriculum, class size, facilities, internships, equipment and instrumentation needs, and faculty perspectives. Other program visitations included Saint Paul College and Minneapolis Community and Technical College in Minnesota. These two community colleges had both biotechnology and chemical technology training programs in place. The program offered at Minneapolis Community and Technical College has a transferable program to the university which provided an even deeper understanding of building a more sustainable program with a transfer option.

In addition to Bio-Link's website, http://www.bio-link.org/home/ , the North Carolina State University Biotechnology Center websites, http://www.btec.ncsu.edu/about/partners/ncbc.php and http://www.ncbiotech.org/content/community-college-programs were used for an online exploration of the centers and various biotechnology training programs. These explorations provided information for not only a potential ATE center in Oregon but also a wide variety of industry-specific training programs. Topics that can be explored through the previously mentioned websites include: (a) partnerships with high schools, industry, and universities, (b) biotechnology degrees and certificates, (c) ongoing projects in the biosciences, (d) program development, and (e) employers of bioscience technicians. Programs offered by Davidson County Community College, Alamance Community College, Asheville-Buncombe Technical Community College, and Beaufort County Community College were used to assist in the formulation of a potential biotechnology and/or chemical technology program at Linn-Benton Community College.

Potential Linn-Benton Community College Biotechnology Training Program

Using the information from the focus groups, the on-site interviews, the survey, the DACUM, and the program visitations, a potential transferable biotechnology associates degree program was designed. A program involving Jamestown Community College and the University at Buffalo was used to assist in designing a transferable biotechnology training program and potential dual partnership agreement between LBCC and higher education institutions, see Appendix A. Descriptions for the courses within the designed program can be found in Appendix B.

The PI (chemistry faculty) and Co-PI (biology faculty) compared the skills identified from the various research methods with the courses in the biotechnology training program. The results of this discussion are contained in Appendix C. The current curriculum, laboratories, laboratory experiments, and instrumentation for chemistry and biology will need to be modified to fit the industry desired skill sets. However, the PI and Co-PI feel with the appropriate and adequate support from the college, grants, and industry these modifications are not barriers to program development.

Biotechnology Career Pathways

K-12 education is where curiosity with science begins, and a regional center in Oregon can assist and support teachers who in turn reach many thousands of students across the state. Support for K-12 teachers may be provided through industry summer internships, conferences, or summer workshops. Summer workshops and internships can provide teachers from K-12 with professional development to provide the training they need in the many areas of biotechnology. These summer workshops can: (a) provide hands-on activities that engage students and improve learning (b) include an introduction to the science behind biotechnology, and (c) provide hands-on opportunities for participants to learn how to present biotechnology activities in their classrooms. Through a regional center topics in bioscience can include agricultural and marine biotechnology, microarray technology, and bioinformatics. With appropriate funding these workshops could be free to the K-12 teacher and possibly even have a stipend associated with attendance. With K-12 in mind a biotechnology career pathway was designed as demonstrated in figure 5.

LBCC PROPOSED CAREER PATHWAYS ROADMAP – Biotechnology & Bioscience

Starting Point

High School Students

- Engage in career exploration activities
- Complete a job shadow
- Complete high school science courses
- Earn college credit through College Now

See your high school counselor for recommended courses

Beyond High School

- High School Graduate
- ABE (Adult Basic Ed)
- GED
- Retrain for a new career

- Improve reading, writing math, speaking skills
- Engage in career exploration
- Learn study skills
- Upgrade technical skills

Enter from High School

Corvallis High
Crescent Valley High
West Albany High
South Albany High
Lebanon High
Sweet Home High

Enter from Industry or Higher Ed

Prerequisite: AAS or BS in Chemistry, Biology or related science

Linn-Benton Community College – Admissions & Background

Location – Linn-Benton Community College

Admission to the College | Advising | Tuition and Fees | Financial Aid

LBCC Bioscience Laboratory Technician Certificate

Course Descriptions

Background Information: National Science Foundation Biotechnology Grant

LBCC Biotechnology 2-year Associate of Applied Science Degree

Course Descriptions

Background Information: National Science Foundation Biotechnology Grant

Labor Market Resources

- Occupational Outlook Handbook: Science Laboratory Technicians- Bureau of Labor Statistics
- OLMIS Occupational Information Center: Biological Technicians Occupations in Oregon
- Oregon Bioscience Association
- BioLink: Educating the Biotechnology Workforce
- Career Pathways Career Options
- Northwest Food Processors Association

Related Bachelor Degree and Transfer Connections

There are opportunities for educational advancement. **Some credits may transfer**. Check with your Advisor.

BS at Oregon State University (OSU)
BS at Oregon Health & Science University (OHSU)
BS at Portland State University (PSU)
BS at Western Oregon University (WOU)

General higher education & transfer information

- Oregon University System
- Oregon Community Colleges
- Map of Post-Secondary Institutions in Oregon
- LBCC's Transfer Connections
- Oregon Student Access Commission
- Career Training Options

Figure 5: Possible Biotechnology Career Pathway

Findings and Recommendations

The Executive Summary from the report *The Dimensions and Contributions of the Bioscience Industry in Oregon* indicated that, unlike most industry sectors, the bioscience industry consists of various activities that do not fit precisely into a single category (Josephson, 2009). According to Josephson, the bioscience industry of Oregon consists of two main components: (1) companies that apply science and technology to provide products and services related to life and (2) companies that encompass the life science research activities at universities and hospitals. This grant's survey respondents indicated ten related or more specific bioscience areas: (a) medical device, (b) bio-tech, (c) bio-agricultural, (d) pharmaceutical, (e) biomanufacturing, (f) chemical, (g) education, (h) consulting, (i) research, and (j) capital venture.

The following internet link provides a depiction of the geographical locations of bioscience industry throughout the state of Oregon: http://public.tableausoftware.com/views/AllThreeSurveys_Mapping/General. The link is interactive for users to specifically look at the individual subsectors throughout Oregon as well as the Portland Area. There are also tabs at the top of the page that allow individuals to assess the survey data collected for the questions associated with the: (a) type of industry, (b) hiring considerations, (c) number of process technician positions, (d) number of manufacturing technicians, (e) number of laboratory technicians, and (f) potential for hiring in the next 3-5 years. Additional tabs allow individuals to assess the average range of ratings of respondents by geographic area for basic, soft, and safety science technician skill sets.

This grant's research found that Oregon's bioscience industry has "much" to "moderate" difficulty filling specific positions like scientists and engineers, production workforce, and technicians (process and laboratory). The survey, focus groups, and interview data further indicated a strong interest for industry to maintain their current technicians and to cultivate a qualified bioscience technician workforce.

Bioscience employment opportunities exist for trained workers largely due to the need to fill replacement job openings. According to the Oregon Employment Department (2013) the bioscience technician employment outlook in 2010 was somewhat larger than the statewide average employment in all jobs. In addition, the total number of job openings for the bioscience technician is projected to be somewhat higher than the statewide employment average through 2020. More specifically the following projected job openings for science technicians were indicated: (a) 1,452 biological technicians, (b) 146 chemical technicians, and (c) 322 agricultural and food science technicians (Oregon Employment Department, 2013).

The grant's survey indicated that some of the more notable current challenges in keeping a trained workforce are: (a) finding time for training, (b) affording training, (c) internal planning capacity (d) having an adequate supply of skilled entry level workers, and (e) availability of quality training needed to keep the incumbent workforce up to speed. In addition, the research indicated there was no significant difference in the future challenges in the areas noted above as compared with the current situation. Without some form of intervention the challenges do not appear to the respondents as becoming lessened. This indicates a potential need for both an ATE center in addition to an industry-specific designed training program offered by a community college. An ATE center would provide the avenue for the collaboration of standards, dissemination of information, development of program training curricula, and much more for the bioscience industry sectors and academia. Training programs offered by the community college designed to address the specific needs of local science industry can assist in community employment as well as development endeavors.

Sixty one percent of this grant survey's respondents indicated a strong desire to hire science technicians who meet the criteria described in the survey instrument while another 25% indicated at least somewhat of an interest. When asked to project the number of science technician positions the respondents would like to fill in the next three to five years within their organizations, 45% of the survey respondents were uncertain at the time of the survey. However, 54% of the respondents anticipate position openings in the future.

Comparatively overall, the entry level worker was described as less skillful than the incumbent worker across the set of both technical and non-technical skills. In general, reading and writing for both the entry level and incumbent worker is a shared concern. The research indicates that employers recognize a lack of oral and written communication skills, as well as in reading comprehension. For years, those involved with professional technical training have been clamoring for soft skills to be incorporated into the curricula (Backus, 2009)**.** The non-technical skill areas respondents noted as deficient for entry level and incumbent workers are gap areas a community college could work with industry to address through a comprehensive training program. Integrating academic and professional technical education can develop more well-rounded students who will manifest self-motivation, adaptability, and interpersonal skills on the job (Backus, 2009).

This grant's research team designed a potential biotechnology associate's degree program. The seamless transfer of a bioscience training program's course credits to a regional four-year college was analyzed in the current study. Incorporating transfer as a feature of professional technical education provides many opportunities for students as well as challenges for postsecondary education (Bragg, 1997; Grubb 1997). The ACS (2006a) recommended community colleges develop articulation agreements with four year institutions that allow students to complete their training programs and transfer their coursework. Transfer options allow students to continue their education and complete higher degrees. Furthermore, Backus (2009) found training programs having less than 35 students enrolled are more sustainable if they offer transferability of course credits. A cohort program of 24 students offered at Linn-Benton Community College would certainly be classified in this category. Comments and suggestions were solicited from the Chemistry, Biology, and Physics departments at Western Oregon University with respect to the potential program's articulation. Although the institutions are far from reaching a transfer agreement, the task does not appear to be insurmountable at this time. A signed agreement between institutions would need in-depth curriculum development for lecture and laboratory content as well as assessments approved by both institutions. The agreement should also include commitments by industry and academia for which collaboration is an integral part of the endeavor.

Successful partnerships are realized through robust and sustainable goals and policies. The report, "Science Educational Policies for Sustainable Reform" (ACS, 2004), recommended community colleges develop partnerships with employers for training and retraining of the workforce. Partnerships require the collaboration and joint effort of faculty, college administration, and business and industry representatives (Backus, 2009). Referring to community colleges, a report by ChemTechLinks (ACS, 2006a) stated, “It is essential to participate in a healthy alliance with industry and other community partners to maintain a successful technician education program” (p. 4).

Successful partnerships between industry and a college are characterized as having the ability to: (1) determine the needs of a company and (2) design, deliver, and update the training curriculum to addresses the latest technologies and industry practices (Backus, 2009; Frenzel, 2003; York, 1995; Zinser, 2003). Academic/Private-Sector advisory boards assist in program development and allow for greater input by business and industry thereby improving the desired outcomes of curriculum design. Participants of the focus groups indicated a cohort-style training program with industry input would provide “real world” laboratory experience via practicum and internships. Experiential learning can be a strong asset to professional technical training programs because it allows students to: (a) gain exposure to a particular career field, (b) learn about their likes, dislikes, interests, and values, (c) build their skills and résumé, (d) expand a network of contacts, and (e) develop insight into what skills and abilities employers require (Backus, 2009).

Bioscience technician workers typically need an Associate's degree to enter this occupation; although individuals with a Bachelor's degree may have a competitive advantage (Oregon Employment Department, 2013). However, not everyone agrees. During the on-site interviews one company indicated that they were beginning to “rethink their entry-level requirements” for basic laboratory technicians. This company typically hires four-year graduate employees but is now advocating that people with a two-year degree or certificate in basic biology and chemistry laboratory procedures would be a better fit. Overall, individuals in the focus groups and in-depth company interviews saw value in hiring laboratory technicians with a two-year degree or certificate.

Focus groups strongly endorsed movement toward a science (biology and/or chemistry) technician two-year degree. In addition, a majority of the survey respondents showed a strong interest in hiring employees with a science-based technician skill set. Participants stressed the technician of the future ideally comes with a holistic set of skills; including the skills that companies are currently obtaining through on-the-job training. In-depth interview participants saw value in a well-rounded program of biology and chemistry with embedded laboratory skills. This implies the need for a collaboratively designed curriculum for a training program to assist in meeting these objectives.

Research participants agreed a bioscience training program should focus on the increasing presence of regulatory oversight, increased use of automation, and hazardous materials response certification. In addition, program curricula development should be an on-going process, with input from both college and industry personnel. Updating curricula should include regular modifications through the review of material to ensure its currency and relevancy by both academics and industry (Backus, 2009).

While the job setting for each type of technician may be different, the training in basic biology, chemistry, mathematics, laboratory and communication skills is similar. Survey participants, focus groups and interviewees agreed that all technicians should share the common goals of using safe practices, developing teamwork, and continuing to progress in their knowledge of basic scientific principles and efficient laboratory techniques. These findings are consistent with the national survey results published by

Backus (2009) which indicated the most important nontechnical tasks for training programs are to develop critical thinking and communication skills, and instill the attributes of teamwork, flexibility, safety consciousness, and an appreciation for lifelong learning. Providing this comprehensive education is one of the many challenges facing community colleges in their quest for sustainable bioscience training programs.

The industry skill sets (technical, non-technical, and safety) presented in this research are similar to a majority of the presented technical and non-technical skill sets from the national ATE center (Bio-Link, n.d.). The findings of this research indicate a heavy emphasis on the non-technical skills of ethics, following directions, thoroughness, reliability, coping with change, computer skills, problem solving, critical thinking, and teamwork. Important emphases were placed on technical skills for following safety protocols, documenting and maintaining records, following standard operating procedures, proper handling and troubleshooting of instrumentation, basic chemistry and biology laboratory skills, and hazardous materials handling.

Public and private secondary school partnerships with Linn-Benton Community College are strong. There are many opportunities for high school age students through the college's foundations and assets. LBCC offers high school students the chance to earn college credit while still enrolled in high school. Credits can be earned in college preparation courses, lower division transfer courses, and in career and technical courses. In addition, high school students may take LBCC classes and use the credit for both college and high school. These opportunities that currently exist can be expanded to include a biotechnology training program. A bioscience technician career pathway was examined by this grant's research to include secondary education. This option will likely peak attention and provide opportunity for Oregonians interested in the biosciences career.

Recommendations

Despite the slow recovery from the recent economic recession, the State of Oregon employment outlook for bioscience technicians is somewhat larger than the statewide average employment (Oregon Employment Department, 2013). Projections through 2020 show the prospect for a number of new and replacement technician level jobs added to the state's scientific workforce, with job openings occurring both within the Willamette Valley and the Portland Metro Areas.

Oregon's bioscience industry could benefit from an Advanced Technology Education (ATE) center with joint leadership from the Oregon Bioscience Association and higher education. This leadership could assist in the collaboration of certificate, degree, and standard skill set requirements for the entry level and incumbent employee in the various regions throughout Oregon. This research team feels an ATE center located in the Portland area would be appropriate. Portland Community College currently has a bioscience technician training program and therefore has the experience to provide leadership to other programs. In addition, the Oregon Bioscience Association is located in Portland and already serves the industry statewide. With the collaborative leadership of the association and academia, a strengthening in the employability skills of Oregonians should lead to a more appropriately skilled workforce for industry. Not only would this joint leadership provide collaboration across industry sectors with higher education, but it could play a significant roll with K-12 as well. An ATE center could provide assistance in the development of career pathways that begin early on in the education of future Oregonians and strengthen the workforce.

The findings of this grant's research show that science laboratory technician skill-sets required by local industry vary between the geographic regions; indicating that the bioscience sector would best be served by multiple training programs tailored to regional workforce needs. A science technician training program at Linn-Benton Community College could assist the Willamette Valley bioscience industry in providing the desired skill sets for employees.

Though more work needs to be done in this area, conversations between LBCC and local universities indicate the potential to develop a science technician training program that allows for transferability between community colleges and four-year university programs. Transferability between community colleges and universities creates a career pathway for technicians to redefine their opportunities within an organization, and is thusly of significant interest to employers. Furthermore, to maximize employment opportunities and leverage resources between training programs, program structure should also consider transferability of courses and skill-sets between regional community colleges with science technician training programs.

Based on the findings of this study, the research team recommends the implementation of: (1) a transferable science technician training program within the Willamette Valley, and (2) an National Science Foundation funded ATE Center of Excellence serving all of Oregon and other partnering states. Oregon community colleges should seek private, state and federal funding to accomplish these objectives, thus ensuring Oregon remains relevant within the international bioscience market and can meet the changing training needs of Oregon’s workforce.

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APPENDICES

Appendix A: Dual Partnership Agreement for Biotechnology Program

Appendix B: Potential Program Course Descriptions

Appendix C: Skill and Course Alignments

Appendix A: Dual Partnership Agreement for Biotechnology Program

Between Linn-Benton Community College and ______________________

Purpose of Agreement: This document establishes the transfer articulation between Linn-Benton Community College and ___________________. Its purpose is to afford students the opportunity to prepare for and plan their college careers, and to facilitate the transfer process from the Associate in Science (A.S.) Biotechnology degree program at Linn-Benton Community College to the Bachelor of Science (B.S.) or Applied Bachelor of Science (B.A.S.) Biotechnology (or Bioscience) degree program at _____________________.

General Guarantee of Admission and Standing**:** Students who graduate from Linn-Benton Community College with the A.S. Biotechnology degree are guaranteed acceptance into the ______________ degree program at ________________ provided they have a minimum Linn-Benton Community College cumulative grade point average of 2.5. Students who transfer 90 or more credit hours to __________________ are guaranteed full junior standing. _______________ does not limit the number of credits accepted for transfer.

General Guarantee of Opportunity to Graduate: Students who graduate from Linn-Benton Community College having earned a minimum grade of C for at least 72 credit hours from among the courses listed in Appendix A of this agreement are guaranteed the opportunity to earn the *B.S. Biotechnology* degree with six quarters of normal coursework at _____________________. At least 45 of the credit quarter hours used toward a ________________ degree program must be earned by successfully completing _______________ courses. In addition, at least 30 of the final 45 quarter credit hours of any program must be earned through ________________ courses.

Appendix A continued

LBCC College Courses	Credit Hours	College or University Articulated Course Equivalent
Core Program Requirements		
BI 211 Principles of Biology	4	____________________
BI 212 Principles of Biology	4	____________________
BI 213 Principles of Biology	4	____________________
*BI 234 Microbiology	4	____________________
*BI ??? Genetics	4	____________________
*BI 214 Cell and Molecular Biology	4	____________________
*BI ??? Biotechnology Techniques	2	____________________
CH 221 General Chemistry	5	____________________
CH 222 General Chemistry	5	____________________
CH 223 General Chemistry	5	____________________
CH 241 Organic Chemistry	4	____________________
CH 242 Organic Chemistry	4	____________________
CH 243 Organic Chemistry	4	____________________
MTH 251 Differential Calculus	5	____________________
PH 201 General Physics	5	____________________
PH 202 General Physics	5	____________________
*New or Redesigned Courses		
General Education Requirements		
WR 121 English Composition	3	____________________
WR 227 Technical Writing	3	____________________
COMM 111 Fundamentals of Speech, or COMM 112 Introduction to Persuasion, or COMM 218 Interpersonal Communication	3	____________________
MTH 112 Trigonometry	4	____________________
PE 231 Lifetime Health & Fitness	3	____________________
Perspectives		
Physical Science (CH 221)	4	____________________
Biological Science (BI 211)	4	____________________
Biological or Physical Science (BI 212)	4	____________________
Cultural Diversity	3	____________________
Literature and the Arts	3	____________________
Social Processes & Institutions	3	____________________
Difference, Power & Discrimination	3	____________________
Western Culture	3	____________________

Appendix A continued

Optional Coursework

BI 231 Human Anatomy and Physiology	5	______________________
BI 232 Human Anatomy and Physiology	5	______________________
BI 233 Human Anatomy and Physiology	5	______________________
MTH 243 Introduction to Statistics	4	______________________
CS 120 Digital Literacy	3	______________________
IN 1.197 Intro to Industrial Computers	1	______________________

Appendix B: Potential Program Course Descriptions

BI 211 Principles of Biology
One of three introductory courses intended for science majors: biochemistry, botany, zoology, forestry, microbiology, fisheries and wildlife, agriculture, pre-medical, pre-dental, pre-veterinary, pre-pharmacy, biology, etc. A survey of biodiversity: the major groups of organisms, their classification, and their evolutionary relationships. Biology 211, 212 and 213 need not be taken in numerical order. Includes a laboratory component. Corequisite: CH 112 Chemistry for Health Occupations or CH 150 Preparatory Chemistry or CH 121 College Chemistry (only offered at OSU) or CH 221 General Chemistry.

BI 212 Principles of Biology
One of three introductory courses intended for science majors: biochemistry, botany, zoology, forestry, microbiology, fisheries and wildlife, agriculture, premedical, pre-dental, pre-veterinary, pre-pharmacy, biology, etc. Focuses on cell structure and metabolism and the structure and function of plants and animals. Biology 211, 212 and 213 need not be taken in numerical order. Includes a laboratory component. Corequisite: CH 112 Chemistry for Health Occupations or CH 150 Preparatory Chemistry or CH 121 College Chemistry (only offered at OSU) or CH 221 General Chemistry.

BI 213 Principles of Biology
One of three introductory courses intended for science majors: biochemistry, botany, zoology, forestry, microbiology, fisheries and wildlife, agriculture, premedical, pre-dental, pre-veterinary, pre-pharmacy, biology, etc. Focuses on genetics, evolution, ecology and behavior. Biology 211, 212 and 213 need not be taken in numerical order. Includes a laboratory component. Corequisite: CH 112 Chemistry for Health Occupations or CH 150 Preparatory Chemistry or CH 121 College Chemistry (only offered at OSU) or CH 221 General Chemistry.

*** BI 234 Microbiology (Redesigned)**
Students will be able to identify the microorganisms of importance to medicine, industry, as well as the natural world. Topics will include microbial taxonomy; cultivation; metabolism; genetics; physical; chemical; and chemotherapeutic agents of microbial control; host defense mechanisms and immunology; virology; epidemiology; selected bacterial, fungal, and protozoan. In the laboratory, students will become skilled in appropriate techniques for handling bacterial cultures, identifying specimens, and implementing and evaluating various standard diagnostic procedures. Prerequisite: BI 211, 212, and 213.

*** BI ??? Genetics (NEW)**
Students will be able to identify the basic concepts of heredity, structure and replication of chromosomes, gene and chromosomal mutations, gene linkage and chromosome mapping, transcription and translation, regulation of gene expression, mechanisms of

mutation, recombination and repair, population genetics, molecular evolution, cloning and recombinant DNA technology, and other contemporary topics.
Prerequisites: BI 211; Corequisite: CH 221

***BI 214 Cell and Molecular Biology (NEW)**
This course will examine the structure and function of living cells. The course extends and adds to the fundamental cell biology knowledge students acquire in BI 211, Principles of Biology. In the lecture component of the course, students will learn about energy use by cells; cellular proteins and enzymes; DNA, chromosomes, and gene expression; membrane structure and transport; cellular organelles; cell communication; the cytoskeleton; and control of the cell cycle and cell death. In the laboratory portion of the course, students will learn how to perform contemporary methods used to manipulate cells and molecules within cells. Prerequisite: BI 211

*** BI ??? Biotechnology Techniques (NEW)**
This course provides hands-on experience with the techniques and instrumentation used in the modern biotechnology laboratory. Students will be introduced to critical thinking and problem associated with Biology, Genetics, and Cell and Molecular Biology. Problem solving will draw upon the basic techniques of molecular biology used in the study of gene structure and function, including DNA/ RNA and plasmid isolation, protein extraction, Southern blotting and western blotting, PCR, gene cloning, and others. Prerequisite: BI ???, Genetics; Corequisite: BI 214.

*** BI ??? Biotechnology Program Internship (NEW)**
This course provides students with practical experience in supervised employment related to biology. Students identify job performance objectives and work a specified number of hours during the term. Note: Credits are based on identified objectives and number of hours worked. Prerequisite: Biotechnology Program Coordinator’s approval.

CH 221 General Chemistry
A general chemistry sequence for students majoring in most sciences, pharmacy, and chemical engineering. First course of a three-term sequence for students in science, engineering and the professional health programs. Includes a laboratory component. Prerequisite: MTH 095 Intermediate Algebra and any one of the following: a passing score on the chemistry entrance exam, or CH 150 Preparatory Chemistry with a grade of “C” or better, or CH 121 College Chemistry with a grade of “C” or better, or CH 112 Chemistry for Health Occupations with a grade of “C” or better. Corequisite: MTH 111 College Algebra. To schedule an entrance exam or for further information contact: Linda Taylor at taylorl@linnbenton.edu or 541-917-4741.

CH 222 General Chemistry
A general chemistry sequence for students majoring in most sciences, pharmacy, and chemical engineering. The second course of a three-term sequence for students in science,

engineering and the professional health programs. Includes a laboratory component. Prerequisites: CH 221 General Chemistry with a grade of "C" or better and MTH 111 College Algebra with a grade of "C" or better.

CH 223 General Chemistry
A general chemistry sequence for students majoring in most sciences, pharmacy, and chemical engineering. Third course of a three-term sequence for students in science, engineering and the professional health programs. Includes a laboratory component. Prerequisite: CH 222 General Chemistry with a grade of "C" or better

CH 241 Organic Chemistry
The first course of a three-term sequence for students in the sciences, chemical engineering, and professional health programs. Topics include nomenclature, in-depth treatment of major classes of organic compounds, mechanisms and synthesis. Includes a laboratory component. May be eligible for upper-division credit at a four-year institution. For details, please see the program description for an Associate of Science with an emphasis in Chemistry. Prerequisite: CH 123 College Chemistry or CH 223 General Chemistry with grades of "C" or better.

CH 242 Organic Chemistry
The second course of a three-term sequence for students in the sciences, chemical engineering, and professional health programs. Topics include nomenclature, in-depth treatment of major classes of organic compounds, spectroscopy, mechanisms and synthesis. Includes a laboratory component. May be eligible for upper-division credit at a four-year institution. For details, please see the program description for an Associate of Science with an emphasis in Chemistry. Prerequisite: CH 241 Organic Chemistry with a grade of "C" or better.

CH 243 Organic Chemistry
The third course of a three-term sequence for students in the sciences, chemical engineering, and professional health programs. Topics include nomenclature, in-depth treatment of major classes of organic compounds, spectroscopy, mechanisms and synthesis. Includes a laboratory component. This course may be eligible for upper division credit at a four-year institution. For details, please see the program description for an Associate of Science with an emphasis in Chemistry. Prerequisite: CH 242 Organic Chemistry with a grade of "C" or better.

MTH 251 Differential Calculus
The first course in the calculus sequence for students majoring in mathematics, science and engineering. Limits and derivatives are approached using graphical, numeric and symbolic methods. Linear approximations, related rates, curve sketching and optimization are among the applications of differentiation covered in this course. Prerequisite: MTH 112 Trigonometry or equivalent.

Appendix B continued

PH 201 General Physics
The first of a three-term sequence of introductory college physics for students who are planning to transfer credit to a four-year college or university, or for anyone desiring an understanding of physics principles. Topics covered include: mechanics, force and motion in one-and two-dimensions, circular motion, gravitation, energy, linear and angular momentum, and simple harmonic motion. Lab exercises help elucidate physical principles and teach measurement and analysis skills. Prerequisite: Completion of MTH 112 Trigonometry with a grade of “C” or better. Recommended: High school physics, GS 104 Principles of Physics, or PH 199 Computational Physics. This course includes a laboratory component.

PH 202 General Physics
The second of a three-term sequence of introductory college physics for students who are planning to transfer credit to a four-year college or university, or for anyone desiring an understanding of physics principles. The themes of thermodynamics, waves and electricity will be explored. Specific topics include fluids, temperature, heat, thermodynamics, wave motion, sound, electrostatic force, field, potential, and circuits. Prerequisite: Completion of PH 201 General Physics with a “C” or better. This course includes a laboratory component.

MTH 243 Introduction to Statistics
An introductory statistics course emphasizing interpretation of statistical results. The course focuses on sampling procedures, experimental design, descriptive statistics, and inferential statistical techniques to analyze survey and experimental data from a wide range of fields including health care, biology, psychology, physics and agriculture. Includes basic concepts in graphical interpretation of one and two variable data, probability, probability distributions (binomial, normal, t-Distribution, and chi-square), confidence intervals for means and proportions, and hypothesis testing. Prerequisite: MTH 111 College Algebra or equivalent.

CS 120 Digital Literacy
Designed as a survey course to familiarize students with computer concepts including software and hardware, software applications, and living online leading towards digital computer literacy. Introduces students to Windows file management, Internet and email concepts and techniques including professionalism and etiquette, word processing, spreadsheet software, and presentation graphics skills in a hands-on setting.

IN 1.197 Introduction to Industrial Computers
Introduces students to basic applications of computers in industry; a variety of applications including Windows, Word, Excel, AutoCAD©, and PLC programming basics. Students will have hands-on opportunities with these applications and will be able to identify strengths and weaknesses.

BI 231 Human Anatomy and Physiology
The first term of an introduction to the structure and function of the human body. Benefits students in the health professions and physical education, but is valuable to others interested in the anatomy and physiology of the body. Focuses on the structure and function of the cell, basic biochemistry, tissues, skin, skeleton and muscles. Includes a laboratory component. Prerequisites: MTH 065 Elementary Algebra and BI 112 Cell Biology for Health Occupations with a grade "C" or better, BI 212 Principles of Biology with a grade "C" or better, or equivalent.

Students who are currently enrolled in BI 231 or BI 232 will be allowed to register for the next sequence course (BI 232 or BI 233) before priority registration for continuing students. Current BI 231 and BI 232 faculty will announce the day, time and restrictions for this special registration day. Students will be permitted to register for only the Anatomy and Physiology class at this time. All holds on student accounts must be resolved prior to this registration day. Students must earn a "C" or better in BI 231 or BI 232 to move to the next sequence course. The week after grades are submitted, students who earned less than a "C" in BI 232 or BI 233 will be dropped from the pre-registered sequence course.

BI 232 Human Anatomy and Physiology
The second term of an introduction to the structure and function of the human body. Benefits students in the health professions and physical education, but is valuable to others interested in the anatomy and physiology of the body. Focuses on the nervous system, endocrine system, and cardiovascular system. Includes a laboratory component. Prerequisite: BI 231 Human Anatomy and Physiology.

Students who are currently enrolled in BI 231 or BI 232 will be allowed to register for the next sequence course (BI 232 or BI 233) before priority registration for continuing students. Current BI 231 and BI 232 faculty will announce the day, time and restrictions for this special registration day. Students will be permitted to register for only the Anatomy and Physiology class at this time. All holds on student accounts must be resolved prior to this registration day. Students must earn a "C" or better in BI 231 or BI 232 to move to the next sequence course. The week after grades are submitted, students who earned less than a "C" in BI 232 or BI 233 will be dropped from the pre-registered sequence course.

BI 233 Human Anatomy and Physiology
The third term of an introduction to the structure and function of the human body. Benefits students in the health professions and physical education, but is valuable to others interested in the anatomy and physiology of the body. Focuses on the lymphatic system, respiratory system, urinary system, fluid and electrolyte balance, digestive system and reproductive system. Includes a laboratory component. Prerequisite: BI 232 Human Anatomy and Physiology.

Appendix C: Skill and Course Alignments

As advocated for by the focus groups a cohort model of not more than 24 students could be enrolled in the bioscience program. The coursework within the program would be developed by a joint effort from business and academia. The following skill sets identified by the research (focus groups, interviews, visitations, survey, and DACUM) could be embedded in some or all of the program's courses. The following illustrate the potential for how these skill sets could appear throughout a program. Bioscience technicians should be able to:

Program Courses Embedded Skill Sets

- Listen.
- Communicate ideas through peer to peer, in meetings or small groups, and up the organizational structure.
- Speak up and disagree.
- Display good oral, written (including technical writing), and electronic communication with proper grammar.
- Deal with change.
- Be adaptable and flexible.
- Understand continuous improvement.
- Problem solve
- Trouble-shoot.
- Ask questions.
- Utilize time management/set priorities/use time efficiently.
- Be willing to be cross-trained.
- Multi-task.
- Focus when necessary.
- Work with minimal supervision.
- Understand and maintain confidentiality.
- Prioritize in a challenging environment.
- Set work priorities with supervision.
- Maintain lab housekeeping, e.g. clean glassware, work area, clean hood filters.
- Drive research forward.
- Work collaboratively.
- Display critical-thinking and problem-solving.
- Document data appropriately.
- Perform team based collaborative problem-solving.

Appendix C Continued

- Demonstrate a willingness to work.
- Display an overall work ethic.
- Share ownership for the work outcomes.
- Exhibit a professional workplace ethic.
- Demonstrate public speaking skills.
- Show respect for employer.
- Take interest in the business as opposed to being self-absorbed.
- Properly interact with colleagues, supervisors and clients.
- Cope with rapid change and be an active "learner".
- Exhibit leadership skills.
- Work as a team-player and builder.
- Work well with a diverse group of individuals.
- Be thorough and conscientious.
- Take initiative.
- Accept and use constructive criticism.
- Display reliability, timeliness, and good attendance.
- Project understanding of a commitment to the company mission.
- Respect confidentiality of the business environment.
- Attend to detail.
- Display professional comportment.
- Take initiative – see what needs to be done and do it.
- Demonstrate a willingness to learn and be teachable.
- Multi-task and be aware of know personal limits.

Biotechnology Course Skill Sets

- Respect proprietary information, materials.
- Use autoclaves.
- Plate samples and read the plates.
- Contribute to developing test methods.
- Prioritize in a challenging environment.
- Set work priorities with supervision.
- Maintain personal and work boundaries/expectations.
- Apply Lean Manufacturing.
- Blend mechatronics and lab technology.
- Rely on employees with multiple skills (fewer employees = need for greater efficiency

Appendix C Continued

- Collect samples, e.g. water and swab samples.
- Contribute to developing test methods.
- Keep an accurate inventory, e.g. recording accuracy, transaction accuracy, stock room management.
- Maintain inventory of lab supplies and order supplies and reagents as needed.
- Date, label and store supplies and reagents.
- Maintain and store manufactured products inventory.
- Monitor physical properties of reagents, buffers, media and solutions.
- Determine the acceptability and optimum conditions of reagents for tests.
- Package, handle and ship biological materials.
- Prepare and dispense stock reagents, buffers, media and solutions.
- Sterilize reagents, buffers, media and solutions.
- Follow SOPs.
- Comply with FDA and cGOM Regulations.
- Manage process monitoring/process review documentation.
- Maintain, troubleshoot and initiate corrective action to meet production schedules.
- Understand and use Kaiser Principles.
- Understand and commit to quality control, and /or continuous improvement.
- Use sterile technique.
- Obtain, label, and/or assess acceptability of specimen.
- Request tests and match request to test sample.
- Prepare test subjects for sampling.
- Prepare sample for testing.
- Demonstrate the use of sterile fill, lycophilization and packaging.
- Understand and work with increased regulatory oversight.
- Measure a group of unknowns against calibrated standards.
- Adhere to current good manufacturing practices (CGMP).
- Demonstrate good laboratory practices (GLP).
- Use laboratory information management systems (LIMS.)
- Handle new and older instrumentation (i.e. use, calibration, and maintenance).

Biology Course Sequence(s) Skill Sets

- Understand/Perform aseptic technique.
- Plate samples and read the plates.
- Perform electrophoresis.
- Appropriately use laminar flow hoods.

Appendix C Continued

- Have basic understanding of microorganisms.
- Have microbiology skills.
- Use cell culture and sterile processing techniques.
- Understand genome enabled research.
- Use DNA electrophoreses.
- Apply plant materials principles.
- Apply planting or transplanting techniques.
- Apply soil science principles.

Chemistry Course Skills Sets

- Use basic chemistry principles (periodic table, atomic weights, chemical reactions, wet chemistry, molarity, normality).
- Understand pH/acids and bases.
- Demonstrate bench chemistry laboratory skills, e.g. using mechanical and glass pipettes, measuring flasks, bringing something to volume, meniscus, quantitative transfers, titration, and dilutions.
- Prepare buffer solutions.
- Perform extractions.
- Use analytical balances
- Use fume hood appropriately.
- Understand a calibration curve and compare a known to an unknown.
- Use appropriate filtration, titration, and pipetting techniques.
- Calculate, prepare, and execute dilution series.

Combined Chemistry and Biology Course Skill Sets

- Prevent cross-contamination.
- Display technical writing skills.
- Record mistakes/failures appropriately.
- Follow written procedures.
- Understand units of measure, dry/wet volume, multiplication, division, and significant figures.
- Adhere to waste management policies and procedures.
- Adhere to standardized processes such as how to write down processes.
- Show proper documentation of the process or procedure.

Appendix C Continued

- Prepare and transfer solutions.
- Have knowledge of the terminology associated with the job.
- Operate analytical instrumentation (pH meters UV-Vis spectrometers, high-performance liquid chromatography, gas chromatography, infrared spectroscopy, and mass spectrometry).
- Display analytical skills.
- Demonstrate laboratory notebook documentation skills.
- Appropriately clean glassware, dispose of waste, and maintain reagent integrity.
- Set up equipment, monitor, and complete reactions.
- Analyze, measure, and characterize results.
- Collect, record and analyze data for reactions.
- Identify and troubleshoot erroneous results.
- Maintain, operate, and troubleshoot laboratory instruments.
- Maintain, monitor, and correct for temperatures, pressures, levels and flow of equipment.
- Use appropriate laboratory safe practices.
- Write or update and report protocols, SOP's, manuals, reports, and technical summaries.
- Understand attributes of analytical methods.
- Understand method limitations.
- Understand equipment limitations.

Internship

- Use automation.
- Formalize apprenticeships.
- Create strong ties with industry and connect with industry.
- Use advising and mentoring advantageously.
- Perform test/assays: chemical, biological, clinical, environmental, robotic, mechanical.

Computer Course Skill Sets

- Demonstrate computer skills, e.g. Excel, pivot tables, macros, word processing, presentation.
- Use other computer-based systems, e.g. virtual storage.

Appendix C Continued

Math Course Skill Sets

- Demonstrate understanding of averages, standard deviation, rounding, mean/median, basic statistics.
- Demonstrate understanding of principles of logarithms.
- Use regression curves.

Physics Course Skill Sets

- Demonstrate laser safety.
- Display basic knowledge and awareness of radioactivity/radiation safety.

Hazmat Class Certification

- Become certified for hazardous materials response.
- Follow and enforce effective safety procedures, guidelines, and plans.
- Observe, identify, and document safe practices.
- Process and dispose of waste material as per guidelines.
- Comply with government and/or accreditation regulations.
- Follow universal safety precautions.
- Use appropriate safety precautions to handle hazardous biological/chemical materials.

Program Tools and Equipment Requirements: The following is a list of equipment and instrumentation that the DACUM and Focus groups indicated desirable for their training needs. Although some of the equipment listed below is cost and space prohibitive for an educational institution, internships could provide the avenue for the training needs.

Personal Protective Equipment	High-performance Liquid Chromatography
Fast Protein Liquid Chromatography	Infrared spectrophotometers
UV/VIS spectrophotometers	Atomic Absorption
Confocal microscopy	Interstitial Gas Analyzer
Cytometers	Electrophoresis
pH meters	Mass spectrometry
SIE (Specific Ion Electrode	Optical Emission Spectrometry
Scales (basic and analytical)	Gas Chromatograph
Transmission Electron Microscopy	